Winter 2012-2013 ENSO Discussion and Outlook

Andrew Snyder – Meteorologist Intern, NWS Wilmington OH

Since La Niña dissipated last spring, the state of the El Niño Southern Oscillation (ENSO) has been in flux with several subtle shifts, but no dramatic turns. Without any clear signals from this prominent climate driver (its related wintertime impacts over the United States are well known), the upcoming seasonal outlook was especially challenging for climate scientists.

ENSO has remained in a neutral state (neither El Niño nor La Niña; near-normal ocean temperatures) through the fall months. Sea surface temperatures (SSTs) over the central and eastern equatorial Pacific Ocean began rising during the late summer but have since leveled off. Fig. 1 shows this trend, particularly in the Niño 3.4 region, which is typically used to help diagnose the current state of ENSO. In a planar view, Fig. 2 shows an assortment of above and below normal SSTs across the equatorial Pacific Ocean, but no extreme values. Another way to look at the magnitude of the temperature anomalies is to plot a vertical slice of the ocean temperatures. Fig. 3 shows that there aren't any extreme anomalies beneath the ocean's surface. Even though the anomalies have and may continue to rise above 0.5°C at times (which typically delineates a transition to a weak El Niño), conditions are considered ENSO-neutral due to a lack of persistent warming, and none of the ensuing weather pattern transitions in the tropical Pacific Ocean have developed. NOAA's Climate Prediction Center (CPC) considers El Niño or La Niña conditions to occur when the monthly Niño 3.4 Region SST departures meet or exceed +/- 0.5°C, along with consistent atmospheric features. These anomalies must also be forecasted to persist for 3 consecutive months.

During the fall months, our region has experienced a variety of weather: both cool and warm periods, both wet and dry periods, and the unusual pattern surrounding Hurricane Sandy. Can this changeability be expected to continue into the winter season? While large weather swings are more common in fall than winter, a broad look at global patterns doesn't suggest any predominant pattern for the upcoming winter. Let's take a further look, starting with ENSO, which is one of the strongest and most well-predicted drivers of winter weather patterns over the continental United States.

Almost all of the climate prediction computer models dedicated to ENSO are predicting ENSO-neutral conditions to continue through the winter (Fig. 4), with SST anomalies residing on the warm side of average, but less than 0.5°C above average. This high probability (greater than 70%) of ENSO-neutral conditions can be seen in Fig. 5, which also shows the probability of El Niño forming is well below the climatological average. The CPC concurs with the forecast and has discontinued their "El Niño Watch." A "Watch" is issued, according to the CPC, when the environment in the equatorial Pacific basin is favorable for the development of El Niño conditions within the next three months. However, these conditions are no longer expected to be met.

Statistically speaking, what does an ENSO-neutral winter mean for the Ohio Valley? One way to examine the range of possibilities is to plot past observations via box and whisker plots for the Ohio climate zone. The "box" part of the diagram indicates the middle 50% of observations (i.e., the most likely range to occur), with the majority of the remainder observations occurring along the “whiskers.” Temperatures during ENSO-neutral winters have tended to be evenly distributed around the climatological average (Fig. 6). Precipitation during ENSO-neutral winters has been closer to normal than both El Niño and La Niña winters (with a noted lack of extreme values), although the distribution is slightly skewed toward wetter totals (Fig. 7). Note that these charts are designed in reference to ENSO events and not to seasonal averages, although the approximate 30-year climatological average is denoted on the plots for reference.

Another factor that can influence seasonal climate forecasts is the Pacific Decadal Oscillation (PDO). The PDO is similar to ENSO in that its phase is determined by ocean temperatures over the North Pacific Ocean. However, its oscillation between positive and negative phases is much slower than that of ENSO; the mean PDO phase may remain similar for 20-30 year periods. Currently, the PDO is in a negative phase, which means ocean temperatures are above normal in the central North Pacific Ocean. In this phase, a strong Pacific jet stream is favored. Cooler waters along the western coast of North America lead to a buckling of the jet stream over the western and central U.S. and stormy winters for the East Coast.

ENSO is always a main player in the winter weather outlook, as it has fairly high seasonal predictability. However, there are many sub-seasonal climate features that can ultimately determine how the winter plays out. Unlike ENSO, these factors are only predictable on time scales on the order of weeks, so prognosticators commonly refer to them as “wildcards.” The poor predictability precludes any definitive statements about the outcomes of these factors, but the possibilities they bring can be discussed. The Pacific North American (PNA) pattern has one of the highest correlations to Ohio Valley precipitation during the winter, even more so than ENSO. A negative phase of the PNA consists of high pressure over the North Pacific Ocean, with downstream effects over the United States often consisting of zonal (west to east) upper level flow over the Ohio Valley, an active storm track, and heavy precipitation. However, this also often translates to warmer temperatures. The related North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) describe atmospheric pressure tendencies over the North Atlantic Ocean and the Arctic. The negative phases of these oscillations lead to weaker jet stream winds and the ability for cold arctic air to make it farther south into the United States. The Madden-Julian Oscillation (MJO) is essentially an atmospheric wave induced by thunderstorms in the Indian Ocean that slowly propagates eastward and can affect the jet stream pattern over the United States. The frequency and magnitude of these events are highly variable. The Quasi-Biennial zonal wind Oscillation (QBO) describes wind patterns in the stratosphere. This feature tends to have a greater influence in weak ENSO years. In a negative phase (where it resides as of this writing), the stratospheric winds blow from east to west, and can induce “blocking” patterns in which cold air masses can become locked in place over the eastern United States. All of these factors can both balance and offset each other through the course of the winter, making definitive seasonal predictions quite challenging. Often, highly variable weather can result!

Other large scale land surface characteristics can have an impact on air mass “modification.” High early season snowpack over both Siberia and northern North America has shown a correlation to the ability of strong Arctic air masses to develop and move into the lower 48 states. Snow pack built up impressively over the Northern Hemisphere during the fall months (Fig. 8). However, a noted upswing during the fall of 2011 decreased and then fluctuated into the winter months of 2011-2012 and had seemingly little impact on the winter weather patterns in the U.S.

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CPC’s winter outlooks typically heavily lean on ENSO forecasts, which are one of the more reliable seasonal weather predictors, with slow, seasonal evolutions, and known impacts on the United States. Without a clear signal from ENSO, the CPC feels that the winter climate could be much more variable and unpredictable. Therefore, they have placed a large portion of the Ohio Valley into the “Equal Chances” category for both temperature (Fig. 9) and precipitation (Fig. 10). **It is important to note the “Equal Chances” designation does *not* mean that the outlook is calling for a “normal” winter.** Rather, it means there are equal chances (33.3% each) for temperatures and precipitation to be either above, below, or near normal. However, the CPC does introduce increasing chances of above normal precipitation south of the Ohio River, based on climate computer model predictions and the negative phase of the PDO. They also indicated that the AO/NAO could play the biggest role during this winter. Keep in mind that these are seasonal trend forecasts and that daily and weekly weather will vary significantly.

With the high amount of unpredictability in the climate system, we can see if history provides any similar scenarios to compare to this year. As far as ENSO is concerned, this is the first time since ENSO records began in 1950 that a weakly warm/neutral year has followed a weak La Niña year. So instead, let’s expand this search to include both ENSO-neutral and a negative PDO. Sometimes this pattern can favor an active jet stream over the central U.S. and a buildup of Arctic air over Canada. The Ohio Valley is often on the interface of the warm and cold air and can have periods of both. The last such winter was 2008-2009. January was very cold and snowy, while December and February were near normal temperature-wise, but had very little snow (at Cincinnati, Dayton, and Columbus). As a result, the seasonal snowfall was below normal.

Summary:

Without a prominent ENSO phase this year, other factors will likely play a role in this winter’s weather patterns. During last winter, the positive NAO favored well above average temperatures over the eastern United States. Such patterns can be either sporadic or longer-lasting, so it is difficult to tell at this point what types of snow patterns may evolve. Considering the PDO, our region could see periods of both above and below normal temperatures. The historical odds do favor above normal precipitation for portions of the region, but whether any of the active storm tracks sync up with cold air is a wildcard. Using a statistical approach, it is unlikely for this winter to be extreme – neither very warm like last winter or extremely cold and snowy. Particular weather impacts on the Ohio Valley will likely depend on the track of individual storm systems, which is only predictable days in advance. More information can be found on the CPC website. The National Weather Service in Chicago has an excellent article about the upcoming winter season as well, but please note their focus is more on northern Illinois.

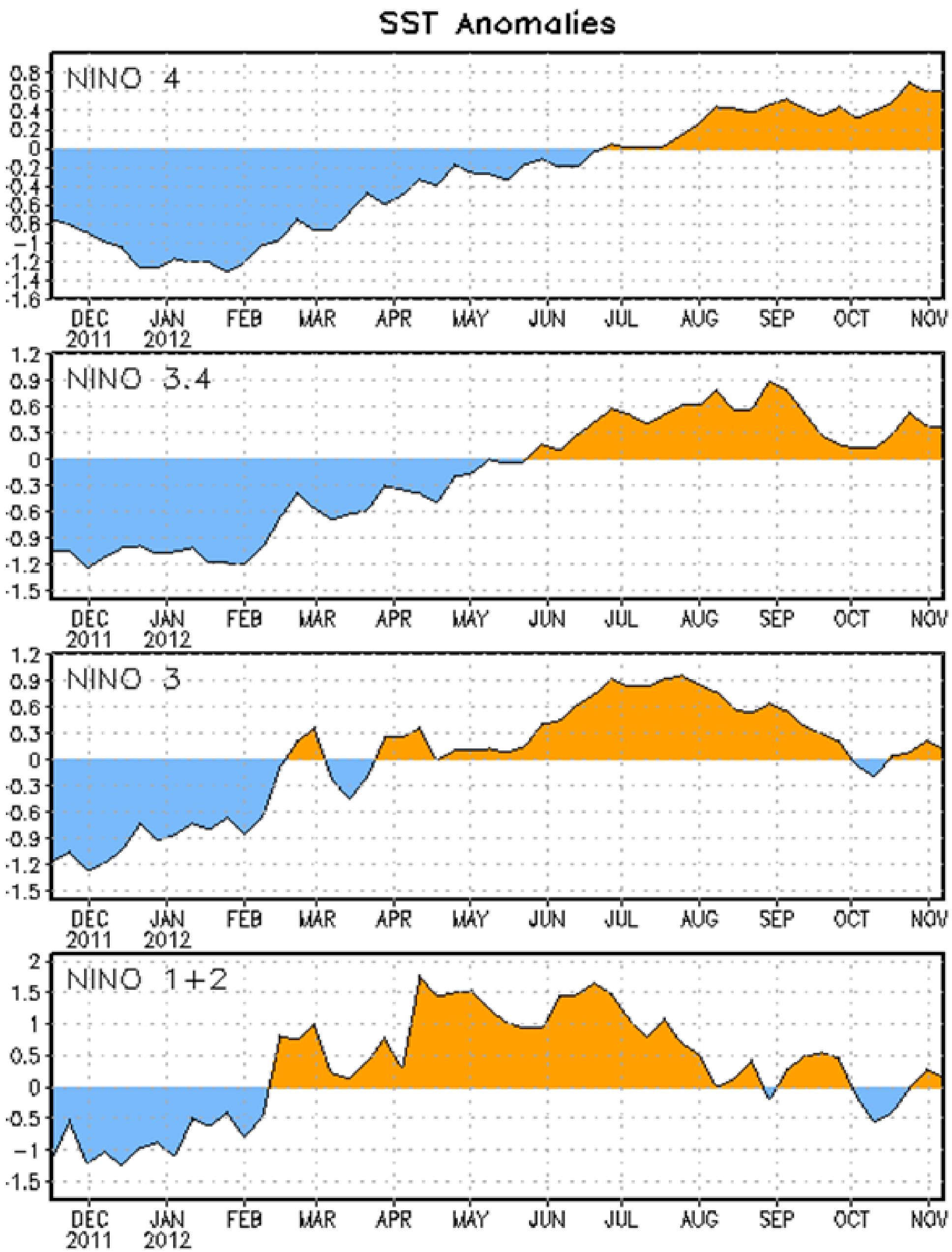

Fig. 1. SST anomaly trends in various regions of the equatorial Pacific Ocean over the past year. The blue color indicates cooler than normal SSTs, and orange represents warmer than normal SSTs. The SSTs in the Niño 3.4 region are typically used to determine the base ENSO state. Some warming occurred recently (right side of graphs) but has leveled off. Image courtesy of CPC.

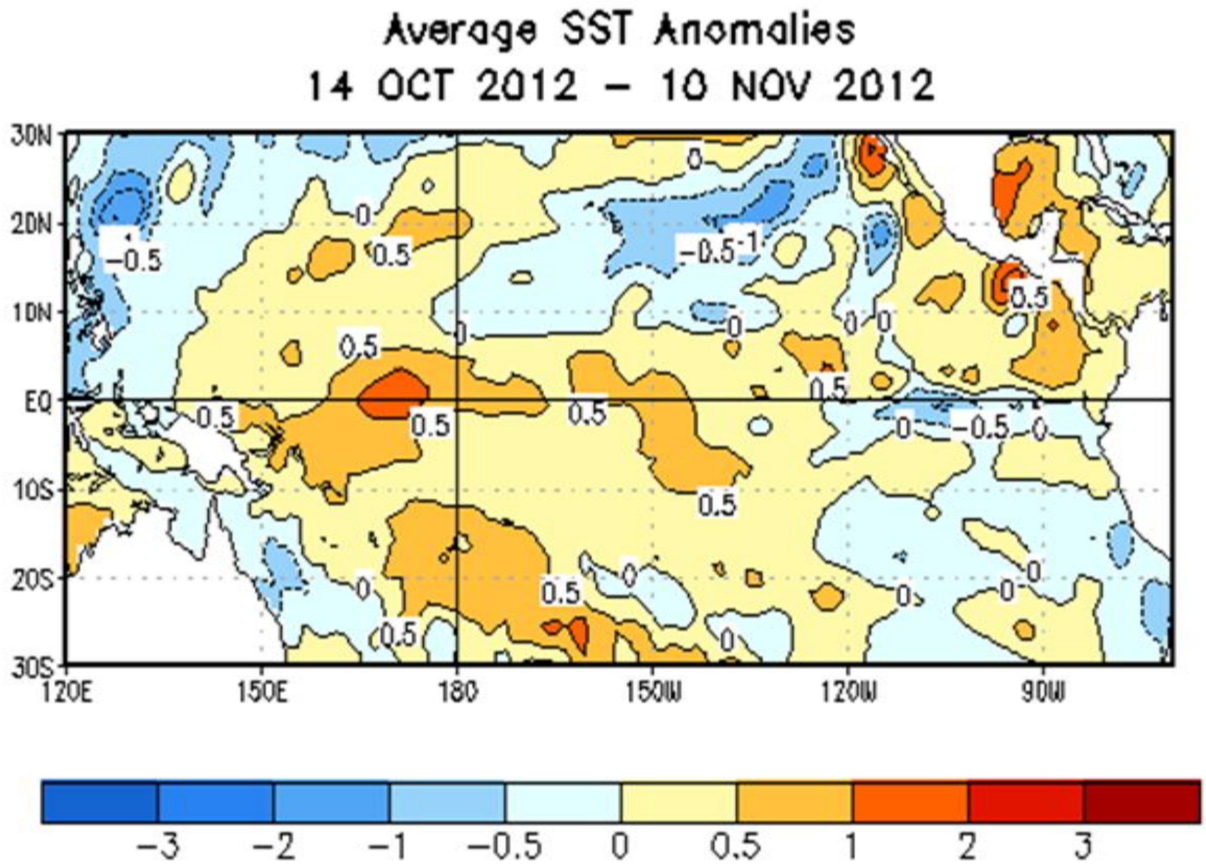

Fig. 2. Average SST anomalies over the equatorial Pacific Ocean during October and November 2012. Reds indicate above normal SSTs, while blues represent below normal values. Currently there are not any extreme values over the eastern Pacific Ocean (right center of map). Image courtesy of CPC.

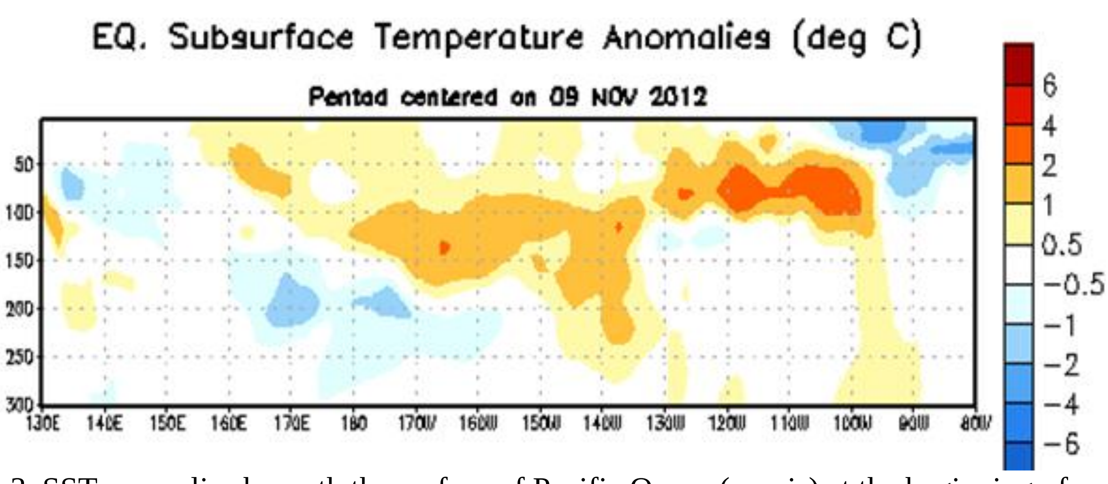

Figure 3. SST anomalies beneath the surface of Pacific Ocean (y-axis) at the beginning of November 2012. Reds indicate above normal SSTs, while blues represent below normal values. No strong trends have been noted in subsurface anomalies. Image courtesy of CPC.

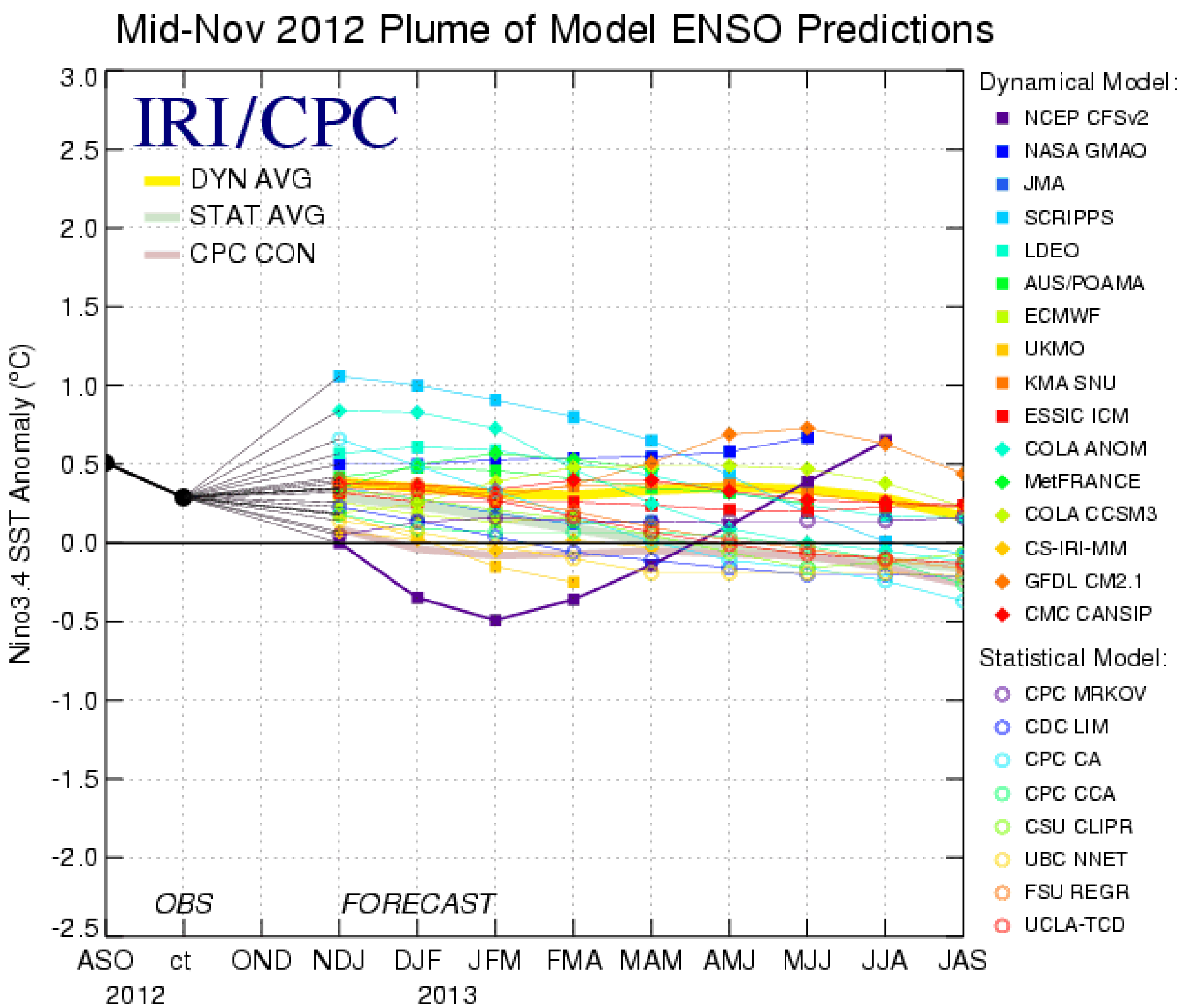

Figure 4. Computer model forecasts of ENSO conditions. Each line represents a different computer forecast of SST anomalies. The solid yellow and beige lines represent the averages of several models. El Niño occurs with persistent anomalies of greater than 0.5ºC, while La Niña has persistent anomalies less than -0.5°C. Note most of the forecasts remain near zero (solid line – ENSO neutral) for the upcoming winter season (DJF). Figure provided by the International Research Institute (IRI) for Climate and Society.

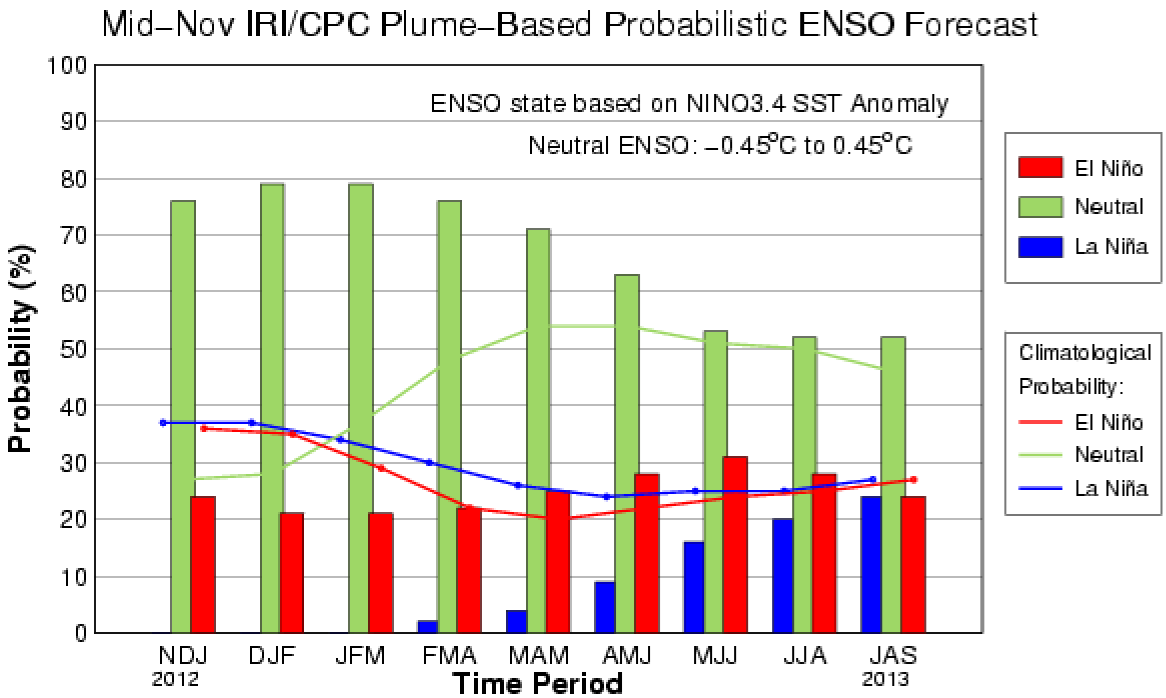

Fig. 5. Computer model probability of each of the three ENSO states occurring in three month increments through July/August/September 2013. ENSO-neutral conditions (green bars) are the most likely ENSO state through the period. Figure provided by the CPC and International Research Institute (IRI) for Climate and Society.

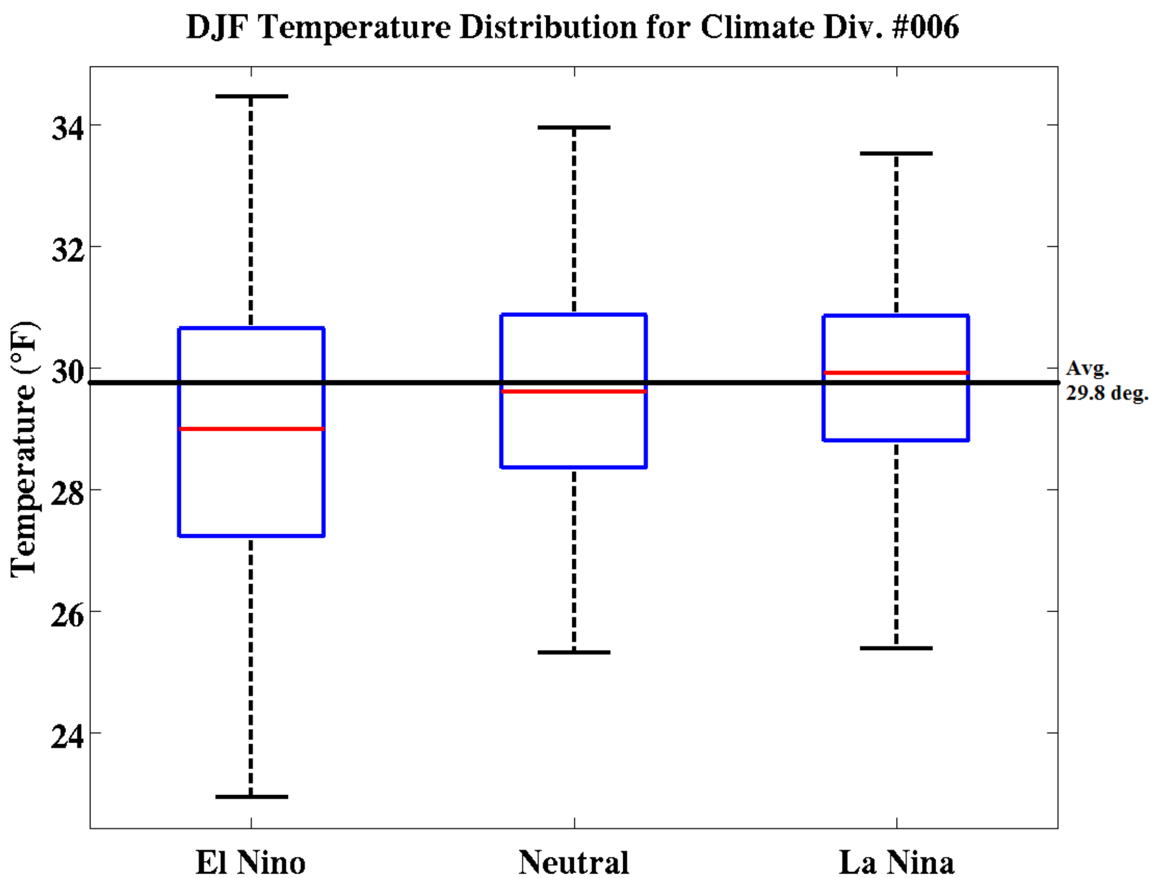

Figure 6. Winter temperature distributions for the Ohio climate division based on ENSO activity. Temperatures during ENSO-neutral years are fairly evenly distributed around the climatological average. Image courtesy of CPC.

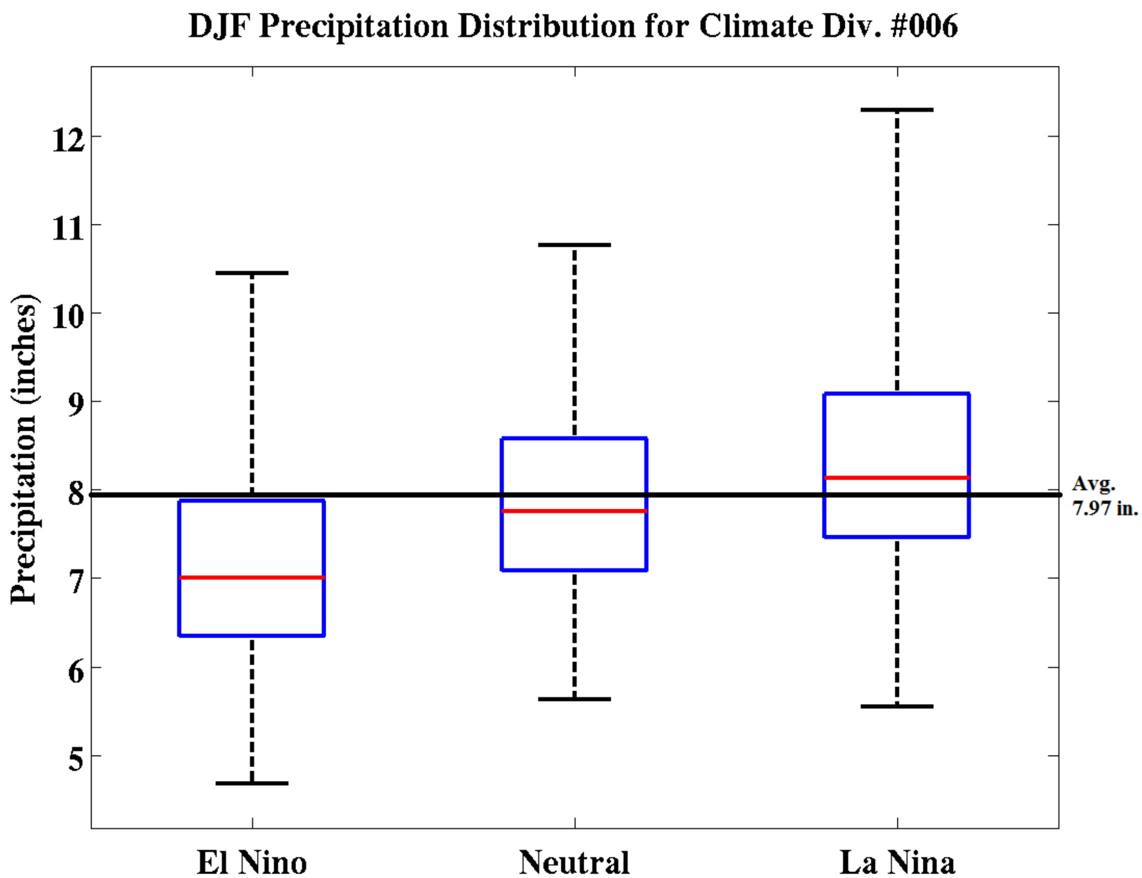

Figure 7. Winter precipitation distributions for the Ohio climate division based on ENSO activity. ENSO-neutral winters fairly evenly distributed around the climatological average. Image courtesy of CPC.

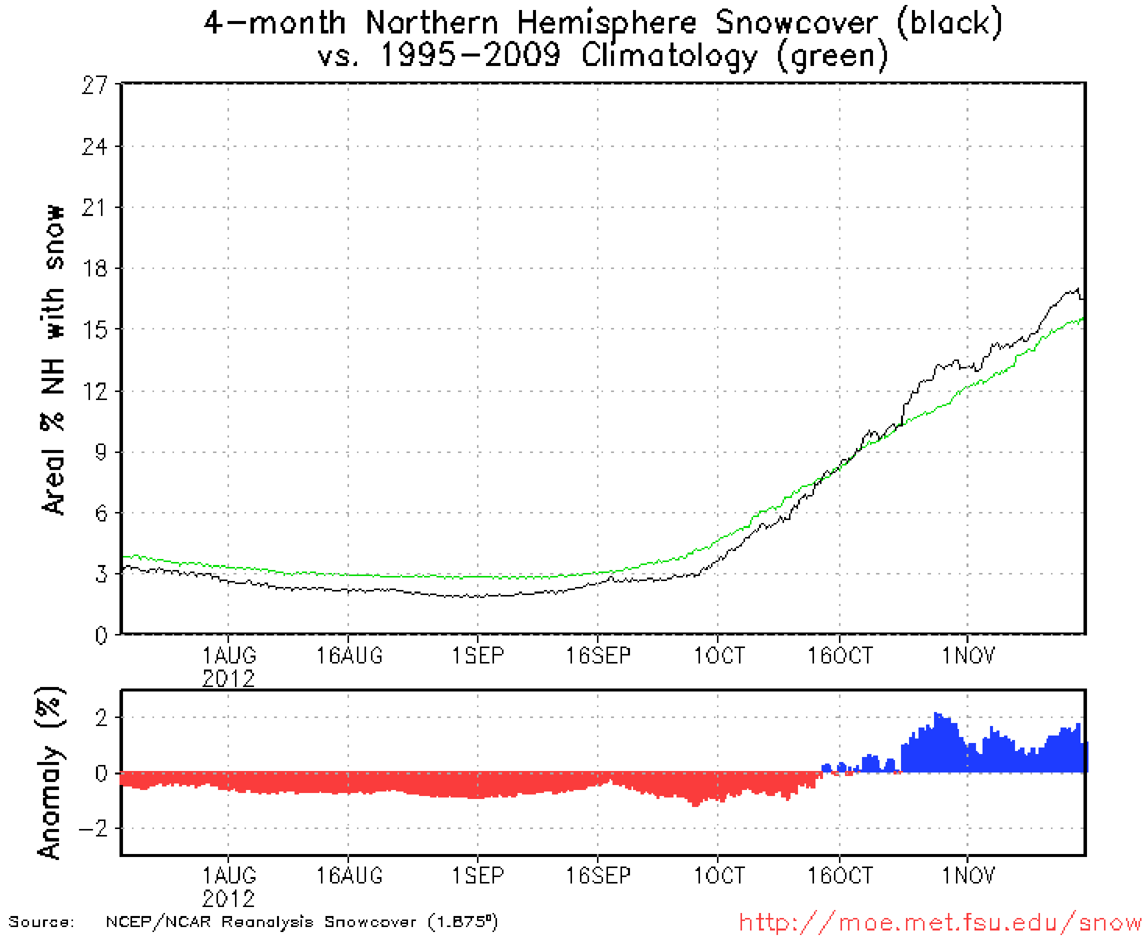

Figure 8. Four-month time series comparing the areal percentage of the Northern Hemisphere covered with snow (black line) and the climatological percentage (green line). In the bottom portion of the plot, the blue colors represent above normal snow cover, while red indicates below normal snowfall. Current time is on the right side of the plot. Image courtesy of Florida State University.

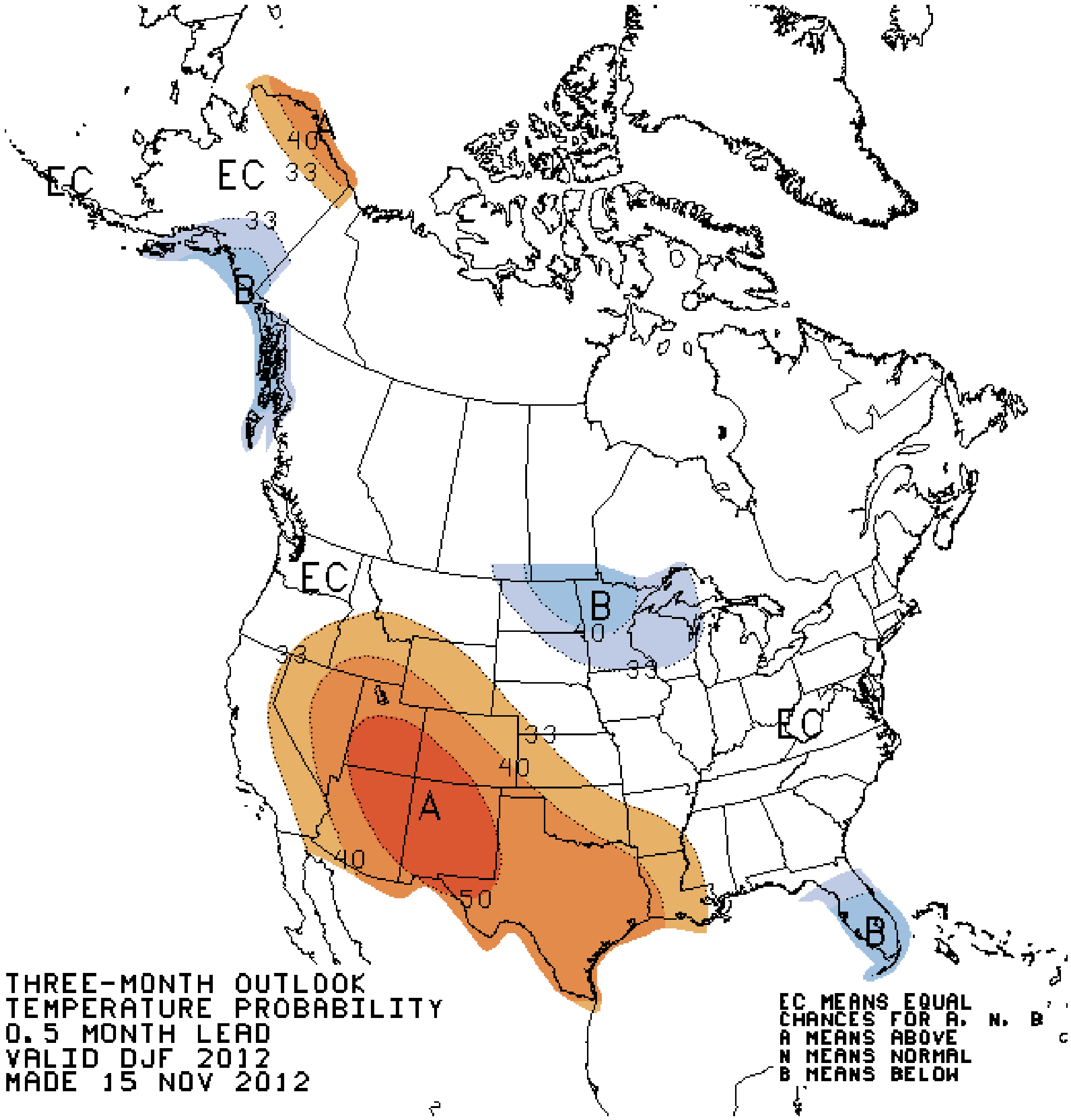

Figure 9. Winter temperature anomaly outlook. The red shading indicates areas where expected conditions support a greater chance of above normal temperatures. Blue shading shows where there are increased chances for below normal temperatures. Image courtesy of CPC.

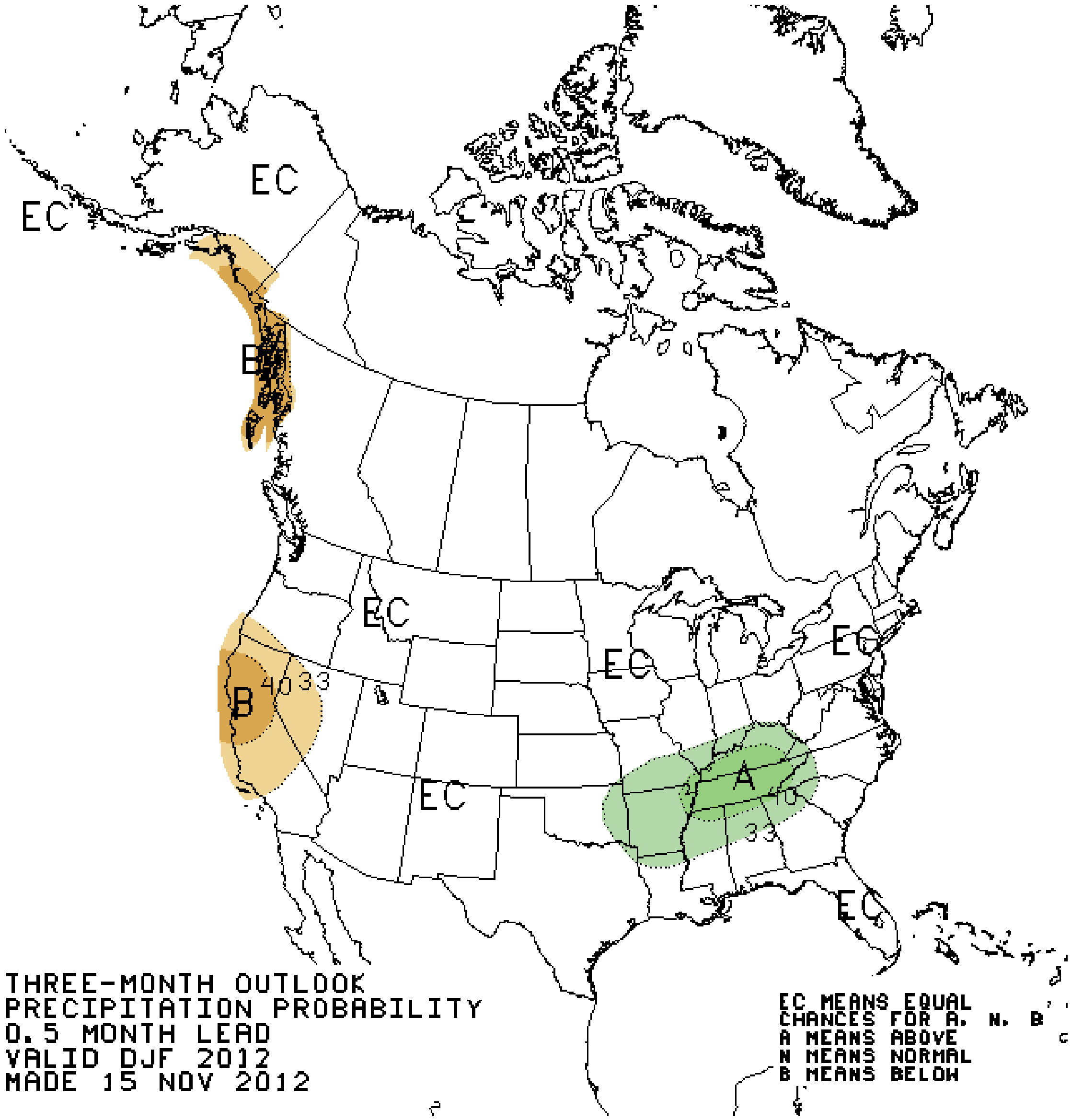

Figure 10. Winter precipitation anomaly outlook. Green shading indicates areas where expected conditions support a greater chance of above normal precipitation, while brown shading indicates where expected conditions support a greater chance of below normal precipitation. Image courtesy of CPC.